



# Fun with Transistors

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## SUMMARY

Playing with transistors lets you in on what makes just about everything in our world work. Transistors are easy to work with, requiring just a few basic steps. In most cases you need to use biasing resistors to control when they turn on and off. Biasing resistors also lower the current needed to switch a transistor on and off. Biasing keeps a transistor in one of its states so it only changes states when you want it to. Biasing helps with signal flow. Generic transistors need biasing. Transistors are current devices and voltage only plays a small part in their operation.

Resistor 1 Main biasing resistor keeps the transistor in the Off or On state. Changing this resistor's value adjust the turn On voltage and current.

Resistor 2 Input voltage and current adjustment to lower the load on what is driving the transistor. Transistors can change state with as little as 2 mA of current.

Resistor 3 Protects the load the transistor is driving. LEDs need a current-limiting resistor to protect them.

You can get packs of transistors at Radio Shack.

NPN (Negative-Positive-Negative): Switches negative voltages with positive voltage control. It has the effect of an inverter.

PNP (Positive-Negative-Positive): Switches positive voltages with negative voltage control. Also an inverter.

MOSFET: Basic performance is like an NPN transistor, but they are much more.

Parts of a transistor ----- MOSFET

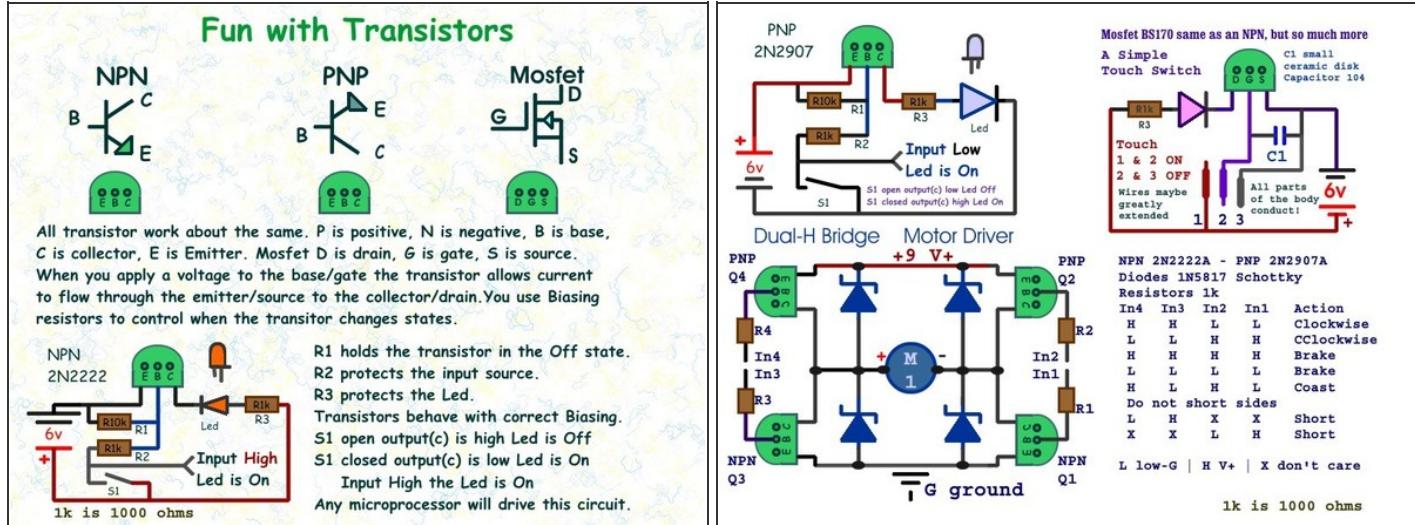
Emitter Input Voltage ----- Source

Collector Output Voltage ----- Drain

Base Controls the states of the transistor. -- Gate

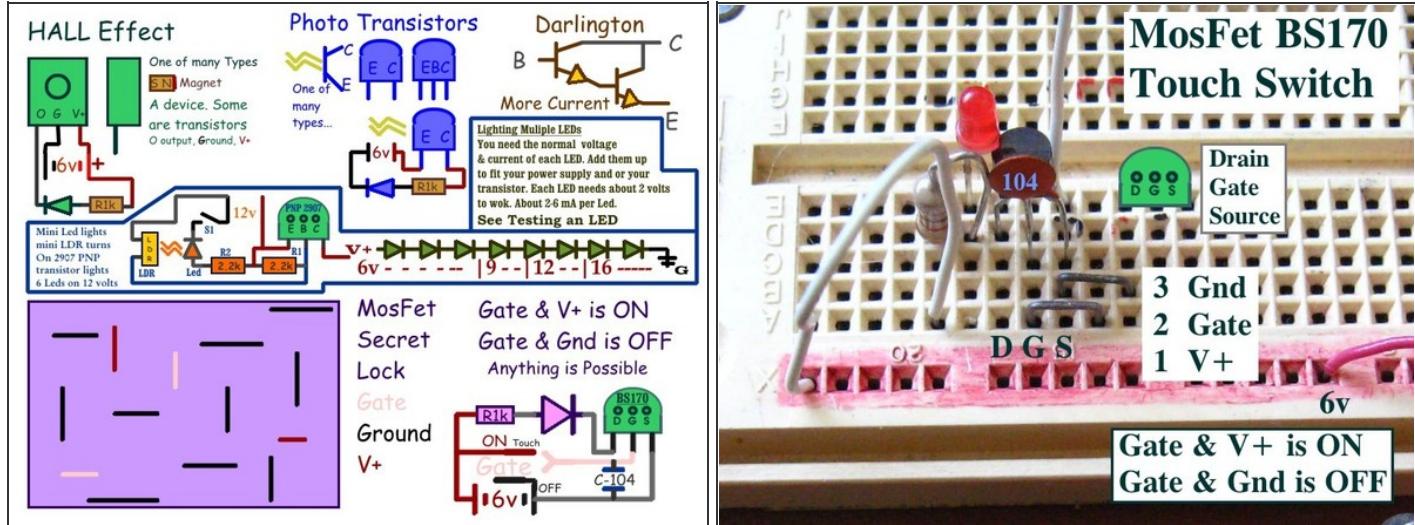
Transistors come in many formats so check the data sheets. Even generics like the 2N2222 or the 2N7906 can handle about 30 mA or maybe up to ten LEDs. They can drive small motors on small vehicles and small 5-volt relays. You can build oscillators, timed switches, animated things and much more.

## Step 1 — Fun with Transistors



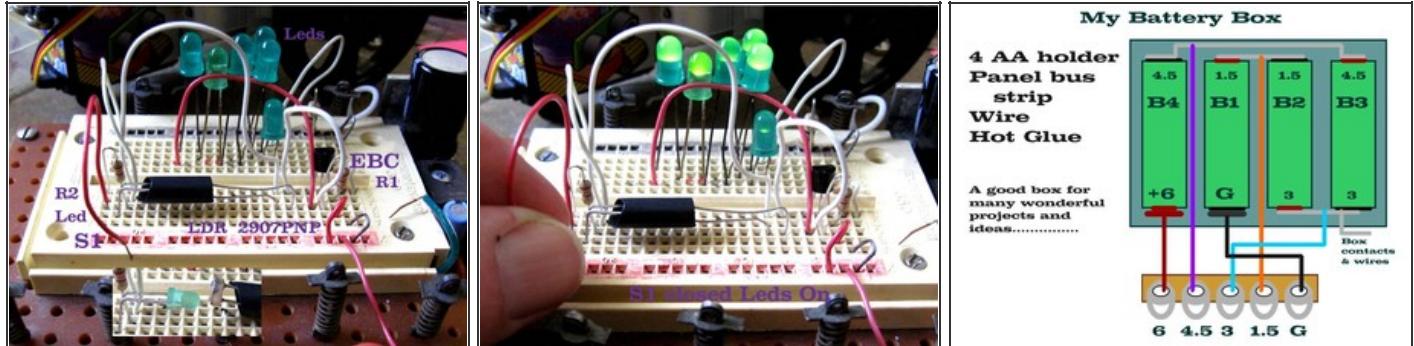
- Most microprocessors cannot drive more than 20 mA on one output pin at a time. This is where transistors come in to drive the outside world. Through biasing you can connect transistors to tri-state outputs. Hi-Z is one state of a tri-state output where the pin is floating. Biasing keeps a transistor from being affected by this type of open circuit. You must use a resistor between the microprocessor pin and the transistor to protect the microprocessor. Use 220 to 1000 ohms.
- Look at the pictures and see that transistors are very easy to use. For each circuit you adjust the biasing resistors so that you drive the transistor with very little current and the load with maximum current. These very basic circuits will drive a lot of useful things. Our world is driven by transistors. Transistors do so much that there is a ton of information out there for you to do anything that you want to with them.

## Step 2



- Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) are fun. Creating a touch switch with them is easy. They remind me of vacuum tubes because the Gate is not directly connected to anything.
- You can test bipolar transistors with a volt-ohm meter; between the Emitter and Base you should read a diode and between Collector and Base another diode. The MOSFET uses the principle of field effect, like a Hall Effect device/transistor that switches when you pass a magnet over it. MOSFETs seem rugged, but they are susceptible to static discharge so keep them in their grounded holder until they are ready for use.
- The touch switch is simple, but powerful. MOSFETs can drive up to 500 mA and can handle about 60 volts. Do not use a touch switch when controlling more than 12 volts. Use another transistor or relay to drive a high-voltage circuit from the touch switch. The touch switch wires can be greatly extended. You can make a secret lock by placing metal tacks, thumbtacks, nails or wires on anything. If the surface is conductive, like metal, you will need to insulate your contacts.

### Step 3



- Lighting multiple LEDs is easy; just add up the voltage and the current of each LED to match your power supply and/or your transistor. You connect them Cathode (-) to Anode (+) down the line. LEDs need about 2 volts and about 2-6 mA each to work. 12 volts lights about 6 LEDs.
- My circuit is a mini LED lighting a mini LDR driving the base of the PNP transistor to light 6 LEDs on 12 volts. The LDR is a Light Dependent Resistor. LDRs have a resistance of about  $160\text{k}\Omega$  in the dark to about  $25\text{k}\Omega$  in the light.
- The biasing resistor worked out to be 2.2k connected to V+ and the Base of the transistor. You have to play with this to find your balance point to keep the transistor off until the LEDs lights. Generic transistors like the 2907 and 2222 have a wide operating window. I used a 10k-25k potentiometer to find my balance point. It is fun. You can light other strings of LEDs with this method.

Transistors are fun.

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